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ABSTRACT

This study investigates the effect of curiosity in first and second grade children as an individual difference variable in learning in a computer-based interactive learner control environment and discusses the implications for instructional designers and educators. The instruction was an art education lesson containing both facts and concepts. The study used two learner control treatments: learner control without advisement, in which learners made decisions about content selection, sequencing, pace, remediation, and other issues; and learner control with advisement, in which learners made the same type of decisions but were advised about their options. There was a significant difference in achievement scores in favor of high curious children in both learner control conditions. The results suggest that differences in curiosity influenced performance within either type of learner control lesson. The differences were independent of grade level or gender. There was a significant interaction between grade level and treatment. First grade subjects performed significantly better with advisement, while second grade subjects performed significantly better without. The data indicate that first graders heeded advisement more than second graders. A possible explanation for the high scores of second graders who functioned without advisement may have been the predominance of high curious subjects in that group. (Contains 44 references.) (KRN)

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Title:

Curiosity as a Personality Variable Influencing Learning in an Interactive Environment

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ABSTRACT

This study investigated the effect of curiosity in first and second grade children as an individual difference variable in learning in a computer-based interactive learner control environment. The instruction was an art education lesson and contained both facts and concepts. Learner control varies by the degree of instructional control which a student has over his/her own learning. In a "complete learner controlled lesson," the learner makes his/her own decisions about issues such as content selection, sequencing, pace, and remediation. In a "learner controlled with advisement lesson," the learner makes the same type of decisions but is provided advisement about the decisions and other learner control options.

This study used two learner control treatments: 1) learner control without advisement (No Advisement) and 2) learner control with advisement (Advisement). High curious subjects, who generally prefer a higher degree of unfamiliarity and uncertainty, were predicted to perform better in a learner control environment than low curious children; both treatments represented a learner control environment. All children regardless of curiosity level were expected to perform better in the Advisement condition than in the No Advisement condition.

As predicted, there was a significant difference in achievement scores in favor of the high curious children in both learner control conditions. The results of this study suggested that differences in curiosity influenced performance within either type of learner control CBIV lesson. The differences were independent of grade level or gender. Research has shown curiosity to be independent of IQ.

Although there were no significant differences overall for treatment, there was a significant interaction between grade level and treatment. Grade one subjects performed significantly better in the Advisement condition than in the No Advisement condition while grade two subjects performed significantly better in the No Advisement treatment. Examination of in-treatment data indicated that the grade one subjects heeded advisement more than the second grade subjects which might explain why that group performed better in the No Advisement treatment. A possible explanation for the unexpectedly high scores of second graders in the No Advisement treatment may have been due to the predominance of high curious subjects in that treatment group; high curious subjects would be expected to perform better in a situation of greater uncertainty than low curious subjects.

Implications of the findings for instructional designers and educators in planning instruction are discussed.

INTRODUCTION

A RECIPE FOR LEARNING

Take a student, place him in a situation
of moderate uncertainty about some topic
and get out of his way while he gets
excited and attentive and directs his
exploration to the source of his uncertainty.
Moreover, research has demonstrated
that he will enjoy his exploration and
the accumulation of knowledge.

Day, 1982, "Curiosity and the Interested Explorer" p. 19

Research on individual differences in cognitive development has largely centered on intellectual aptitudes somewhat diminishing the importance of other aspects of intellectual development, such as intellectual styles (Henderson & Gold, 1983). These styles include cognitive styles, creativity, and the subject of this study, curiosity. Stimulating curiosity in the academic environment is a challenge for educators. Curiosity motivates scholarship. A curious student will want to explore and learn. Curiosity is motivation which is intrinsic as opposed to motivation which comes as a result of external incentives, such as rewards or threats of test taking.

However, not everyone is equally curious. Day (1982) discusses the tendency for some students to become curious more readily. They enjoy opportunities to explore at will while others are less tolerant of unfamiliarity and uncertainty which are almost always present in a situation in which curiosity is aroused.

Not only do people differ in curiosity as a personality trait but environment is thought to play a part as well in the development of curiosity in students. Some students, according to Day (1982), may have had their disposition to be curious dampened at an early age by, for example, being punished for asking too many questions or exhibiting curiosity in numerous ways. It is up to the teacher (or, in the case of technology, the teacher 'function') to give these pupils special training "so that they may become curious once again" (p. 21). Although future studies should address whether trait curiosity can actually be enhanced, the focus of the present study was to explore the effect existing individual differences in curiosity level have on learning in situations which differ in amounts of learner control. Since learner control situations involve different amounts of uncertainty, awareness of individual differences in curiosity potential is essential to the planning and design of instruction.

Planning for how to deal with curiosity is not only a challenge for educators but also for instructional designers and developers of the many interactive learning technologies that are emerging. The present study utilized computer-based interactive video (CBIV). CBIV involves the interfacing of computer technology and video in such a way as to allow active user participation and the opportunity to modify pace, content sequencing, remediation choices, etc., as a result of a viewer's response. The amount of interactivity in a CBIV lesson, however, is based to a large extent on the degree of learner control which is afforded by the lesson.

A number of studies exist on issues related to learner control (e.g., Balson, Manning, Eber & Brooks, 1985; Gay, 1986; Hannafin & Colamaio, 1987; Gay, Trumbell and Smith, 1988) although there are relatively few studies which explore this area with young learners. Prior research suggests that higher achievement scores are possible when there is a component of advisement included in a learner control lesson (Tennyson, 1980; Johansen & Tennyson, 1983; Tennyson, 1984; etc.). This finding was found even for children (Arnone & Grabowski, 1992). There is also substantial research in the area of curiosity and motivation (e.g., Berlyne, 1954; Berlyne, 1960; Maw & Maw 1964; Maw & Maw, 1965; Maw & Maw, 1966; Day, 1968; Wilson, Stuckey & Langevin, 1972; Vidler & Rawan, 1975). These areas of research exist independently of each other, and as such, little is understood about the effect of personality variables such as trait curiosity on learning in a learner control environment or about the interaction of such variables within different learner control situations. Questions remain regarding the effect on performance of one's predisposition to be curious. Will the initially more curious child be more capable of accepting greater degrees of control over their learning because their optimal arousal level is higher (and therefore their comfort zone for uncertainty)? The purpose of this study was to investigate the effect of curiosity as a personality variable on learning in an interactive learner controlled environment.

CURIOSITY

The Construct

Curiosity is often associated with exploratory behavior. The purpose of exploratory behavior is to keep one's level of stimulation at what Berlyne (1960) in his neurophysiological model of arousal calls the "tonus level." (The tonus level is a moderate pleasurable level of stimulation at which an individual functions most effectively.) Berlyne identified two forms of exploratory behavior, "*diversive exploration*" and "*specific exploration*." Diversive exploration occurs as a person seeks new experiences or relief from boredom whereas specific exploration is encountered in situations in which there is conceptual conflict arising out of uncertainty or novelty. Specific exploration is described within the context of epistemic curiosity, that is, "the brand of arousal that motivates the quest for knowledge and is relieved when knowledge is procured" (Berlyne, 1960, p. 274). Epistemic curiosity, then, motivates exploration which resolves the conceptual conflict and returns the individual to a pleasurable tonus level. It is important to note that small increases in stimulation are considered pleasurable because of the resultant return to the tonus level when the conflict is resolved. However, large increases are not considered pleasurable and will result in the individual making attempts to return to the tonus level. One way the individual may attempt to return to the tonus level might be to reduce the stimulation by actually withdrawing from it, for example.

Berlyne's theory of curiosity involves a construct known as "*collative variability*." Collative variability relates to how complex a stimulus is and how easy or difficult it is for the individual to collate, that is, to compare the stimuli to that which the individual is familiar. Collative properties have the potential to increase arousal level and induce curiosity. Day and Berlyne (1971) note, however, that individuals differ in their tolerance and preference for arousal potential. While some individuals may react with interest and exploration to a given amount of arousal potential, another individual may become inefficient and withdraw from the same stimulus.

Day (1982) describes this arousal theory as a curvilinear relationship between efficiency (in terms of learning) and arousal. The optimal level of arousal is one in which the individual enters a Zone Of Curiosity and is willing to approach or explore his/her environment in order to resolve the cognitive conflict that was initiated by the stimuli. When the conflict is resolved generally by seeking answers, etc., the individual returns to a resting place which is the pleasurable tonus level. However, in the event that there is too much stimuli or it is too complex, unfamiliar, or the degree of uncertainty too high, the individual will enter a Zone of Anxiety in which he/she becomes disinterested and inefficient. Performance, it would follow, is negatively affected. Day (1982) writes that "collative variability is to be found in characteristics of stimuli usually labeled with such adjectives as complex, novel, incongruent, difficult, and obscure" (p. 21).

Is this construct separate from intelligence? Day (1968) found no significant correlations between scores on his Test of Specific Curiosity and total intelligence scores. Langevin (1971) found curiosity measures which he tested to be distinct from intelligence on the whole. The arousal model put forth by Day and Berlyne (1971) suggests that intelligence alone is inadequate to account for classroom achievement. They note that the next "most potent factor is probably motivation" (p. 295). Curiosity is motivation which is intrinsic.

Defining curiosity for this study. Maw and Maw (1966) describe curiosity as an arousal state in which the individual desires to know more about one's self or environment. Since much of Maw and Maw's work built upon that of Berlyne, and because their operationalized definition of curiosity involved children, it was particularly useful to the present study. According to Maw and Maw (1964), "...curiosity is demonstrated by an elementary school child when he:

1. reacts positively to new strange, incongruous, or mysterious elements in his environment by moving toward them, by exploring, or by manipulating them.
2. exhibits a need or a desire to know more about himself and/or his environment.
3. scans his surroundings seeking new experiences.
4. persists in examining and exploring stimuli in order to know more about them" (p. 31).

Cecil, Gray, Thornburg, and Ispa (1985) extend the definition of Maw and Maw and consider curiosity to be an arousal state that leads to and is a prerequisite for exploration, play, and creativity. Beswick and Tallmadge (1971) describe a cognitive process theory of curiosity in which curiosity is related to conceptual conflict. In this theory, "the trait of curiosity is defined as an individual's readiness or predisposition to seek, maintain, and resolve conceptual conflicts" (p. 456). In proposing a model of teaching and learning, another author defines curiosity as "the individual's desire to question or investigate" (Parker and Engel, 1984). Penney and McCann (1964) make a distinction between curiosity and reactive curiosity stating that a child may be curious but may not react to his or her curiosity. The definition is very similar to that of Maw and Maw.

Curiosity as trait and state. The literature suggests that curiosity is both a *state* and a *trait* variable (e.g., Day, 1982). As a state, curiosity is a motivational variable which varies depending on the situation in which curiosity is aroused and individual differences. As a trait, curiosity is a more stable variable indicating individual differences in one's potential to experience curiosity. A study by Naylor (1981), gave support for the theoretical distinction between state and trait curiosity. According to Naylor, people who are higher in trait curiosity

should experience curiosity arousal across a wider range of situations and will also have the capacity to experience greater intensities of state curiosity. Berlyne's theory is concerned with curiosity as a state of arousal brought about by stimuli high in collative variability and uncertainty. The theory does not, however, overlook the importance of individual differences or what is generally termed trait curiosity. As mentioned earlier, both Day and Berlyne (1971) agree that individuals differ in tolerance and preference for arousal potential: "When confronted by a specific amount of arousal potential, some people will react with positive affect, interest, and exploration. Others may become overly tense and inefficient, and try to reject, avoid, or withdraw from the source of stimulation" (p. 304). This study investigates trait curiosity. The relation between state and trait curiosity should therefore be important to educators who must balance the amount of stimulation designed to arouse curiosity (the motivational state of curiosity) with an awareness of different individuals' tolerance for arousal potential (curiosity as a trait variable).

Specific and diversive curiosity. Curiosity has been described as both a state and a trait, arising out of both specific and diversive exploration. Berlyne's distinction between specific and diversive exploration was built upon by Day who developed tests of specific and diversive curiosity (Maw & Maw, 1977). Generally, people are pre-disposed to traits associated with being specifically or diversively curious. Referring back to Maw and Maw's (1964) definition of curiosity on page 10, parts 1, 2, and 4 of their definition refer to specific curiosity while part 3 refers to diversive curiosity.

This study investigated differences among children in trait curiosity. However, in as much as the two learner control treatments were designed with different amounts of uncertainty by virtue of advisement versus no advisement, these conditions can be thought of as affecting state curiosity which should affect performance as well. Some authors (e.g., Necka, 1989) discuss strategies designed to nurture trait curiosity through instances of increased state curiosity. Such strategies included brainstorming, role playing, and putting forth questions of the "I wonder if really...?" genre. This seems to indicate that perhaps curiosity as a trait (as opposed to a state) can be enhanced but no longitudinal studies of this sort could be found. A number of studies cited in a review by Maw and Maw (1977) show high and low trait curiosity prevailing under certain conditions in which state curiosity was either consistently stimulated or modelled or it was not. A few other studies discussed in Maw and Maw's review included strategies for raising curiosity by training pupils to ask questions.

The present study was limited to investigating the effect of trait curiosity on learning in a learner control environment.

LEARNER CONTROL

The Construct

Defining learner control for this study. "Learner control" as a general concept, and terms which are related to learner control, such as "advisement," should be defined.

This study uses Milheim and Azbell's (1988) definition of learner control as:

> ...the degree to which a learner can direct his or her own learning process...[The term] most often describes the instructional choices made during a particular lesson. By definition these choices can be made either by the instructional program (as originally defined by the designer) or by the learner during the presentation of materials (p. 3).

A lesson which is highly controlled by the programmer and whose path and possible choices are predetermined is generally called a "designer control" or "program control" lesson. A lesson which allows the learner to control options such as path through the lesson, choice to exit, choice to be remediated, pacing and so on is called a "learner control" lesson. One which affords opportunities for exploration and learner control but with advice ranging from information provided about the student's progress to suggestions for sequencing or other meaningful learning advice is often called "learner control with advisement."

Selected Research on Learner Control

A number of studies show that positive effects have been achieved with the use of interactive video (e.g., Dalton, 1986; Bosco & Wagner, 1988; Hannafin & Colamaio, 1988; Abrams, 1986). Of particular interest are the studies in which learner control was a factor. Some studies have shown positive effects related to increased learner control (e.g., Laurillard, 1984; Merrill, 1975). The addition of some form of **advisement** to a lesson involving learner control has been associated with positive results in increasing achievement (Tennyson, 1980; Tennyson, 1984; Tennyson, Christensen & Park, 1984). Gay (1986) advises that the appropriate level of learner control may be contingent on factors such as individual differences or prior conceptual understanding (Gay, 1986). No studies on learner control looked at adults or children's level of curiosity as a possible influencing variable on successful learning in various learner control situations. Most studies have used college students or adults as subjects. Hannafin (1984) notes that older learners may be better able to utilize the learner control options because of their refined cognitive abilities. Younger subjects (elementary or junior high school age) may not yet have the necessary skills to make the most of such a lesson. Arnone and Grabowski (1992) addressed ways of coping with this developmental challenge by including an advisement function with learner control.

The Bridge Study Between Learner Control and Curiosity

The Arnone and Grabowski study (1992) functioned as the bridge between some of the earlier research on learner control and this doctoral dissertation. For that reason, it is noted as the "bridge study" for the present work. It is one of the few studies which studied young subjects (grades 1 and 2) in research on learner control. The study found a significant difference in achievement between subjects in a total learner control lesson and subjects in a learner control with advisement lesson. That study did not, however, examine trait curiosity and its potential influencing effect on children's learning in different learner control situations. Will a more curious child be more comfortable about exploring in a learner control environment than the less curious child? Will the less curious child show higher performance on achievement in a learner control environment if advisement is provided? Since one aspect of curiosity is willingness to explore and tolerance for uncertainty in a situation, it was expected that there would be overall performance differences between high and low curious subjects in a learner control lesson and that there would be an interaction between curiosity level and the learner control treatment (advisement versus no advisement). The purpose of the present study was to extend the research by Arnone and Grabowski and to explore the effect of trait curiosity level of first and second graders on achievement in a learner control lesson.

PREDICTIONS

The research predictions must be prefaced with an interpretation of how the research in the two separate areas of curiosity and learner control in an interactive learning environment can be merged in a meaningful way. The following discussion proposes one way of thinking about this.

The Merger

It may help to conceptualize "learner control" as a continuum with no learner control on the extreme left and a high amount of learner control on the right. No learner control would mean no opportunities for exploration or choices. Such an environment would essentially shelter the learner from uncertainty since the programmer has basically mapped out a path for the learner.

On the opposite end of the continuum is a high degree of learner control which translates into many opportunities for exploration and choice. By its very nature, high learner control will present an environment which is less familiar, contains more collative variability by virtue of its many options, and has a much higher degree of uncertainty. The learner must encounter the lesson on his or her own, choose to go down a certain path with no guide, decide whether or not to avail himself/herself of the options or leave them be.

The mid-section of this continuum would be learner control with advisement or guidance. In this case, the learner would experience many and perhaps all the options available with a high degree of learner control but with one difference -- advisement. Exploration would take the form of more guided discovery. In essence, collative variability could be quite high but the uncertainty associated with it would be reduced through the guidance which helps in collation. If, as Day and Berlyne (1971) contend, collative variability is essential to arousing curiosity, but that too much collative variability can actually have the effect of depressing curiosity, then the midpoint on the continuum of learner control should be favorable towards increasing performance for all students, and particularly favorable for low curious students.

In the curvilinear relationship between arousal and efficiency of performance that Day (1982) describes, curiosity is a dynamic variable which can be induced or manipulated, while this study investigated curiosity as a stable trait variable. How then can that curve be interpreted in the present study? Using prior research on curiosity as support, it was predicted that the placement of an individual's curve on the arousal axis is partially dependent on how curious that individual is initially. For example, one would expect that, in the presence of stimuli with a high degree of uncertainty, a low curious student may enter the Zone of Anxiety, inefficiency, or disinterest sooner than the high curious child, resulting in a negative effect on one's score on a post treatment achievement test. The low curious child in any environment in which learner control was a factor was predicted to score lower on a post treatment achievement test simply because there is more uncertainty present than in a situation in which there was no learner control (e.g., program control). However, it was also predicted that the low curious child would score higher in a learner control lesson which offers advisement than in the same lesson without advisement.

The authors argue that Learner Control with Advisement encourages movement into the Zone of Curiosity with enough collative variability to be exciting and interesting but enough advisement strategies to reduce the potential for anxiety or inefficiency (in terms of cognitive processing) associated with uncertainty

in a learner control environment. Figure 1 illustrates this interpretation. Higher achievement test scores following the lesson, therefore, were predicted. This effect was expected to be most pronounced with low curious students since their lower optimal level of arousal would be accommodated by the guidance afforded in the Learner Control with Advisement lesson, in essence, keeping them in the Zone of Curiosity longer.

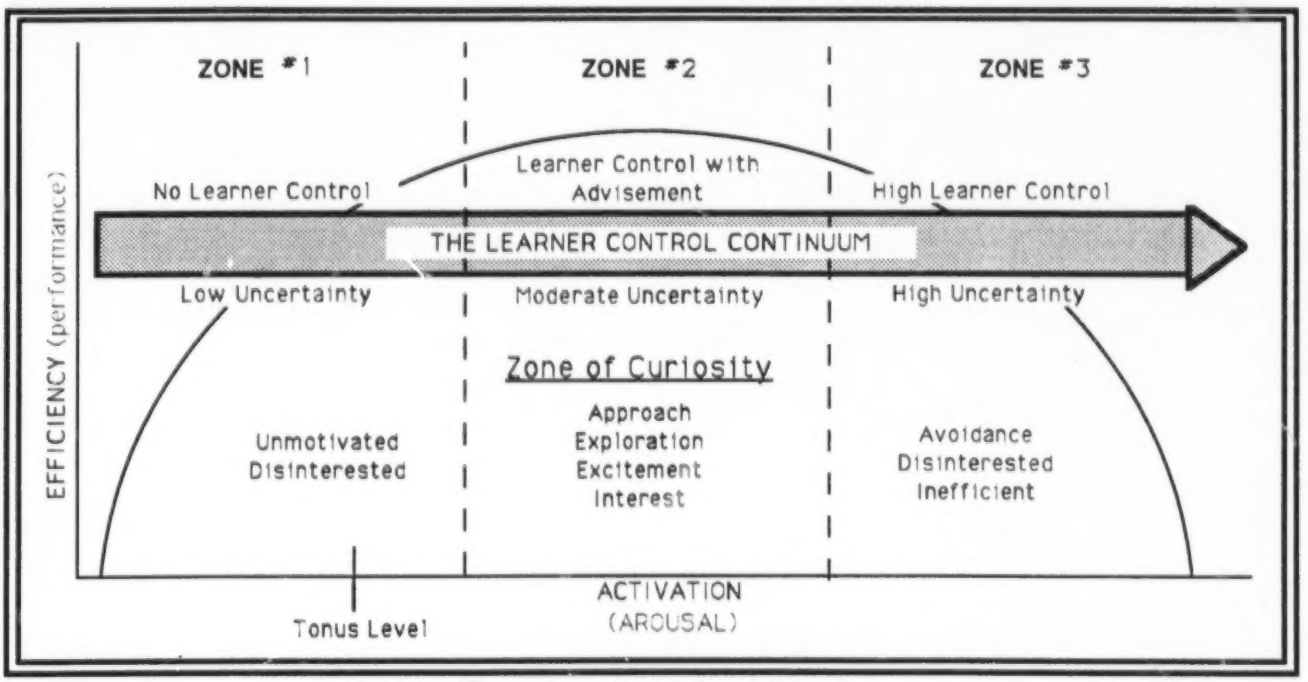

FIGURE 1 ☐ Learner Control and Curiosity
(Adapted from Day, 1982)

Predictions for performance can be related to figure 1 by noting that zone #1 was marked with disinterest and lack of motivation, zone #2 with approach and interest, and zone #3 with avoidance and disinterest. The zones reflect a curvilinear relationship with respect to performance. Figure 2 shows how differences in learner control which range from a low to high degree of uncertainty may be experienced differently by high and low trait curiosity subjects. The numbers within the cells refer to the zones described above and in Figure 1. Arnone and Grabowski (1992) found significant differences between learner control and learner control with advisement (high and moderate uncertainty) but found no significant differences between program control (low uncertainty) and the other treatments. Since this study built on the significant differences found in the previous study, it examined learner control without advisement and learner control with advisement (high and moderate levels of uncertainty), only.

TRAIT CURIOSITY LEVEL

LEARNER CONTROL

Degree of Uncertainty	Low	High
High	3	2 or 3
Moderate	2 or 3	2 or 1
Low	2	1

FIGURE 2 ☐ Predictions of Performance Based on Interaction Between Trait Curiosity and Learner Control

Summary of Predictions

1) Learner control with advisement will be superior to learner control without advisement in promoting achievement in young learners.

2) High curious students will perform better than low curious students in a learner control environment regardless of treatment.

3) There will be an interaction effect between curiosity of students and lesson treatment.

METHOD

This study built on the previous work of Arnone and Grabowski (1992) and utilized the same lesson materials and the same post treatment achievement instrument. Same-age subjects within the same school district assured that a high degree of comparability could be achieved across the two studies. Since the important new dimension was trait curiosity, it was important to hold the other factors as constant as possible.

The study consisted of two parts: 1) a series of three pilot studies related to the testing and development of the curiosity instruments and 2) the main study involving the administration of the curiosity instrument, the intervention, and a post-treatment achievement test. Additionally, the main study involved interviewing a random sample of the subjects about their experience.

Only subjects with parental approval participated. The study was conducted in a school setting as opposed to the lab which afforded some veridicality with a real world learning milieu.

The three pilot studies were conducted in the months before the conduct of the main study to determine the appropriateness of four curiosity instruments for the sample. The first two pilot studies were administered to 18 children each in a different school district than the main study. The third pilot study took place within the same school district as the main study but at a different school and involved 60 children. In addition to providing the basis for selecting the curiosity instruments to be used in the main study, these pilots also contributed to fine-tuning administration procedures prior to the main study.

Subjects

A total of 84 first and second grade students from a suburban school district in Central New York participated in the main study. All 84 subjects were administered the preliminary curiosity measure, received the intervention, and took the achievement test. However, two subjects of the 84 were dropped, one because of computer malfunction (audio drop-out which lasted several minutes during the lesson treatment) and one because of administrator error (administrator did not set up computer for the graphic overlays). A total of 82 subjects remained.

The scores of the 82 subjects on the curiosity measure were collapsed into a categorical variable with two levels of curiosity. On a 20 item test, 36 subjects scored high ($\underline{M}$ = 7.19), 11 subjects scored in the middle ($\underline{M}$ = 12.81) and 35 subjects scored low ($\underline{M}$ = 6.26). As planned, the middle scorers were dropped from the analysis leaving 71 subjects. The difference between the extreme scorers was significant at $\underline{p} < .0001$.

There were 36 high curious subjects and 35 low curious subjects. There were 31 males and 40 females. Thirty-nine subjects were first graders while 32 subjects were second graders. Sixteen first grade subjects were high curious while 23 first grade subjects were low curious. Twenty second grade subjects were high curious while 12 second grade subjects were low curious. Among first grade subjects, 25 were female and 14 were male; among second grade subjects, 15 were female and 17 were male. First graders ranged in age from 6 years 1 month to 7 years 3 months. Second graders ranged in age from 7 years 3 months to 8 years 6 months.

Materials

Materials as input to the study consisted of the curiosity assessment instruments, the lesson, and the two learner control treatments. Materials as output consisted of the post treatment achievement test, lesson log, and interview protocol. In this section, the lesson and the two learner control treatments are discussed. The other materials are discussed under "Instrumentation."

Lesson Description

The lesson content was the same as that used in the bridge study. A subject matter expert in art education provided the content for the treatments. The lesson was designed as a visit to an art museum. The subject matter expert had previously served as Curator of Education for the museum and it was possible to acquire many visuals for the treatments.

The lesson itself included a general introduction and three segments on ceramics, sculptures, and paintings. The content involved both facts and concepts and the lesson provided opportunities for practice, feedback, and remediation.

The lessons were designed for subjects with limited reading experience and contained no text. A narrator was used where text would have been necessary. The use of a touch screen in place of a keyboard further simplified the young learners' task of responding.

An interactive video lesson was developed to be delivered on a Sony Laservision videodisc player interfaced with a MS-DOS compatible computer, a touch-sensitive screen, and headsets. The lesson was programmed using ICON Author. A combination of motion video, slides, and computer graphics was used in the presentation.

CBIV Instructional Treatments

The treatments were labelled 1) Learner control without advisement (No Advisement) and 2) Learner control with advisement (Advisement). Both treatments contained the same essential content and both provided opportunities for practice, remediation, and feedback. Two instructional designers provided judgments on the appropriateness of the treatments in reflecting the constructs of learner control with advisement and learner control without advisement. The dissertation study did involve one change in the treatments. Rather than receiving two opportunities to respond to practice items, the lessons were re-programmed so that subjects were provided the opportunity for remediation or advisement after one incorrect response. The change was made in an attempt to strengthen the advisement treatment.

The average time spent in the learner control with advisement lesson was 13.2 minutes while the average time spent in the learner control without advisement lesson was 15.4 minutes. This did not include the time subjects spent in a pre-lesson warm-up which averaged 3.26 minutes or time spent in taking the post-treatment achievement test.

Learner control without advisement. In the learner control without advisement group, subjects were given the opportunity to sequence the material in any way they chose. Whether to review segments where practice items had been missed was also a decision left to these subjects. Students had the opportunity to omit entire sections or sub-sections, or opt out of the lesson altogether, if they so desired. Students controlled their own pace through the lesson. Additionally, subjects could freeze images on the screen. This was called a "Stop and Look" routine since whenever a particular icon was present, the subject could freeze the image on the screen to explore it more closely. Subjects were familiar with the icon since they were exposed to the icon and its meaning in the pre-lesson practice session.

Learner control with advisement. Subjects in the learner control with advisement group received the same opportunities to explore the lesson as the Learner Control Without Advisement group. However, certain "advisement" strategies were also employed in this group which provided some guidance when poor decisions were made and also encouraged guided discovery. For example, if a student decided to skip out of a section, he/she received this advisement: "Are you sure you want to end the lesson? This next section is very interesting. You might really enjoy it" or "Aren't you going to wonder about what you'll be missing?" Care was taken not to instill fear (related to the expectation of being tested) as a motivation to continue the lesson since such motivation is considered extrinsic and not compatible with the construct of curiosity under study.

While subjects in the learner control without advisement group could take advantage of the "Stop and Look" routine whenever they saw the associated icon appear on the screen, subjects in the learner control with advisement group were advised by the narrator to take advantage of the "Stop and Look" routine to explore the images more closely. The final type of advisement was in the form of a "Stop and Think" routine which generally was preceded by a question to arouse curiosity. For example, after presenting some interesting information about a painting that generally intrigued young children, this question was posed: "Do you wonder how you can tell this from looking at the painting? 'Stop and Think' about it! Then, touch the screen when you are ready to find out." All audio and visuals froze at that point and resumed when the subject touched the screen to proceed. The subject was in control of how long to "Stop and Think;" if the subject wanted to

spend no time in this mode, all he/she had to do was to immediately touch the screen as soon as the narrator finished speaking. Other than the advisement, the instructional content remained the same as the other treatment.

Instrumentation

Curiosity Instruments

The two measures which were selected for use in the main study were:

--Maw and Maw's ***Which To Discuss Test*** (Maw & Maw, 1964) with a practice session and administration directions tailored to primary grades

--Arnone and Sciretta's ***Specific Curiosity Scale for Primary Grades (SCSPG)*** (Arnone & Sciretta, 1991)

The *Which To Discuss Test* does not require reading ability and is a test of specific curiosity which was appropriate for the study. It is comprised of 20 pairs of geometric symbols and figures. One symbol is more familiar and /or balanced than the other in each of the pairs. Preference for the unbalanced or the unfamiliar, according to Maw and Maw (1964) taps into the part of the definition of curiosity in which "a child manifests curiosity to the extent that he 'reacts positively to new, strange, incongruous, or mysterious elements in his environment by moving towards them, by exploring them, or by manipulating them.'" (p. 112). Using the Mann-Whitney U test, this measure showed significant differences between the means of the high and low curious fifth grade children supporting the hypothesis that high curious children select the unbalanced/unfamiliar more often than low curious children. Its reliability is high at .91 computed by the split-half method; Silverstein et al (1981) used Cronbach's alpha to measure the test's internal consistency and calculated it to be .90.

The *Which to Discuss Test* provided the basis of assignment into curiosity groups as it correlated positively with teacher judgment of curiosity in the pilot study, and because Maw and Maw had previously validated the instrument on elementary school children. It also had higher reliability than the newly developed *SCSPG*. In the main study, the *Which To Discuss Test* received the same reliability coefficient using Cronbach's alpha as it did in the pilot studies ($\underline{n}$ = 84, $\underline{r}$ = .90). The reliability coefficient of the *SCSPG* using Cronbach's alpha was $\underline{r}$ = .58 in the main study. The *Which To Discuss Test* showed a significant positive correlation with the *SCSPG* ($\underline{r}$ = .29, $\underline{p}$ = .008). Since the *SCSPG* contained items which encompassed all the aspects of specific curiosity and the *Which To Discuss Test* focused on only one aspect of specific curiosity, another correlation was computed. This analysis involved correlating only those items of the *SCSPG* which represented the aspect of curiosity measured in the *Which To Discuss Test* (i.e., preference for the unfamiliar) with the total score of the *Which To Discuss Test*. This time the correlation was much higher ($\underline{r}$ = .48, $\underline{p}$ = .0001).

Another reason for choosing Maw and Maw's test for the purposes of grouping is that it focused on the aspect of curiosity (preference for the unfamiliar/willingness to explore) most related to the experimental treatments. The primary purpose of administering the *SCSPG* in the main study was to add further construct validity to Maw and Maw's scale and to provide one more opportunity for refinement and analysis of the *SCSPG*.

Scoring for curiosity instruments. In the *Which To Discuss Test*, the child received 1 point for each item which showed a preference for the unfamiliar and 0 points for items which did not indicate this. The total score was the sum of points received. The *Specific Curiosity Scale for Primary Grades* was scored in the same way, that is, subjects received a 1 for responses which indicated specific trait curiosity and a 0 for responses which did not. The minimum total score a subject could receive was 0 and the maximum total score possible was 20 for each of the two measures. The actual scores ranged from a low of 0 to a high of 20 for the *Which To Discuss Test* and a low of 6 and a high of 19 on the *SCSPG*.

Achievement Instrument

The present study used the same achievement test which was used in the bridge study although it was revised for ease of administration. The subject matter expert reviewed the original achievement test for content validity and determined that it adequately represented the content presented in the lesson. A content table of specifications was used to derive the items for the achievement instrument and to insure that the items were weighted in accordance with their importance in the lesson itself.

Part of the challenge of designing materials to measure the effectiveness of the treatments had to do with the type of content to be presented. "Pat" answers are inappropriate in an area such as art education and museums. In measuring achievement, it was necessary to devise an instrument which gave the child the opportunity to be more expressive while demonstrating that he/she had indeed acquired the new information. Although the bridge study also included an instrument to measure whether curiosity had been aroused more by one treatment than another, the present study looked only at achievement.

The achievement test, then, consisted of 8 items which measured whether learning of the content had occurred. A number of points could be accrued for each item. To control for order effect and fatigue, the computer was programmed to randomly generate the order of test items for each subject. Because of the open-ended nature of the questions, it was found in the bridge study to be necessary to distinguish between responses which were specific to the lesson (lesson-related) and those which were not (lesson-unrelated). This study also used the same method in differentiating responses.

Scoring for achievement instrument. In the achievement measure, the subject was presented video still images of aspects of the museum encountered in the lesson such as paintings, sculptures, and ceramics. For each item, the administrator requested the subject to tell her everything the subject knew about the picture. Responses were recorded on a paper and pencil instrument and scored later. After responding, the subject touched the screen to proceed to the next image. The instrument was devised to take somewhat qualitative data and give it points based on 1) recall of facts and concepts introduced in the treatment and 2) number of appropriate responses. The minimum possible score was 0 if the child gave no appropriate responses. The maximum possible score was derived from a content analysis of the lesson. There were 102 possible acceptable responses which were considered lesson-related. The reason for the high number of potential responses was due to the open-ended nature of the instrument. The actual scores ranged from a low of 3 to a high of 40.

Interview Protocol

Twenty-five subjects were randomly selected for brief interviews following the achievement test to garner qualitative information about the subjects' experience in a learner control environment and about decisions they made such as whether or not to exit. Twenty interviews were subsequently transcribed for analysis. Three of the original 25 interviews were inaudible and two subjects who had been interviewed scored in the middle curiosity group and thus were not in the sample for analysis purposes. Fourteen interviews were conducted by one of the authors and the remaining interviews were split up between the administrators.

Through random chance, 11 subjects interviewed were male and 9 were female, 12 subjects were high curious and 8 were low curious, 10 subjects were first graders and 10 subjects were second graders. Nineteen subjects had received the Advisement lesson while 1 subject had received the No Advisement lesson. The subject who received the No Advisement lesson was a first grade high curious female.

Lesson Log

The lesson log was completed by the administrator while the subject was engaged in the lesson. The administrator observed certain decisions made by the subject and recorded the data on the lesson log. The information included data on sequencing decisions, exiting decisions, remediation decisions, reaction to advisement, and how many times each subject used the "Stop and Look" learner control option.

Scoring for lesson log. The data for the lesson logs were recorded by the administrators on the logs. The number of times each subject made the various decisions were later tallied.

Procedures

A number of procedures were related to the conduct, setting, and situational organization of the study. Additionally, certain procedures and precautions were undertaken to protect the study's internal validity.

Administration

Curiosity measures. One month before the subjects in the main study participated in the CBIV lesson, they were administered curiosity measures to determine their trait curiosity level (specific). These measures were administered by one of the authors in a group setting in the actual classrooms of participating subjects. The data for the two measures were collected over four days within a one-week time period. Each instrument was administered to one classroom at a time. The six teachers participating in the study determined the schedule for administration in their respective classrooms. The *Which To Discuss Test* was the first instrument administered and the *SCSPG* was the second. The tests were administered on different days to control for fatigue as a confounding variable. The reason for the order of administration of the two measures was that the *SCSPG* required more time to administer and more listening skills on the part of the students. Since these subjects' test taking experience was limited (especially the first graders) the decision was made to give them the less demanding test first.

Subjects' curiosity scores were collapsed into the categorical variable of high or low curiosity and were assigned to either the learner control without advisement treatment or the learner control with advisement treatment. Block randomization

on the curiosity variable was used to accomplish this. As mentioned earlier, the middle scorers (n = 11) were dropped in deriving the high and low groups and an independent means t-test showed the difference between the high and low groups to be significant at the p =.0001 level. To test that there were no significant differences between the highs in their assignment to the two treatment conditions, and likewise between the lows, ANOVA was used. Results of this analysis indicated that there were no significant differences between the two treatment groups after being assigned the high curious subjects, p = .77. There were also no significant differences between the two treatment groups after being assigned the low curious subjects, p = .85.

Treatments. Subjects were administered the treatments individually and received a pre-lesson warm-up to familiarize them with how to use the touch screen and to introduce several icons which the subject would encounter during the treatment. The achievement test was administered immediately following the treatment. Audiotaped interviews of randomly selected subjects were conducted following the achievement test. As the concluding activity before being returned to class, each subject viewed the same brief entertaining video at a separate laserdisc station. It lasted approximately three minutes. This activity was meant to serve as a distractor from the main content (and learner control condition) of the lessons to help protect the study from the potential for contamination. Since the video was the last thing each saw, it was likely to be the first and most discussed aspect of their experience.

Three treatment administrators were trained during a half-day session two weeks prior to the study. By employing three administrators to administer treatments it was possible for three subjects to participate simultaneously at separate interactive video stations. The interactive video stations were located in a large room within the school the subjects attended. Large dividers separated each station insuring each subject's individual effort and decreasing distractive elements.

All administrators were paid a daily fee for both the training day and the administration days. A total of six administration days over a two-week period was necessary to administer the treatments, achievement tests, and to conduct interviews.

Procedures: Protection of Internal Validity

A number of precautionary administration procedures were undertaken in the bridge study to protect the study's internal validity. These provisions were replicated in the present study. Subjects were blind to which treatment they were receiving. Both treatments were interactive. Administrators were hired for the treatments and post test to control for experimenter bias. Measures were taken to control for distractions during treatments. Administrators participated in a half-day training session in which they eventually reached 100% inter-rater agreement on reporting the data during a beta test. All treatment administrators were blind to the hypotheses of the study. No one had any prior knowledge of the curiosity ratings of any child before administering the treatment and had no idea about any of the expected interactions. Because administrators had to load the designated lesson on the computer for each subject, they necessarily had knowledge of which lesson they were administering, however.

Research Design

To test the predictions that a) subjects in the Learner Control With Advisement treatment (Advisement) will score significantly higher on a posttest of achievement than subjects in the Learner Control Without Advisement treatment (No Advisement), and b) high curiosity subjects will score significantly higher on a posttest of achievement than low curious subjects regardless of treatment, a two-way analysis of variance was conducted. An alpha level of $p \leq .01$ was selected.

To test the prediction that there will be an interaction between curiosity of students and lesson treatment, pairwise multiple comparisons were made choosing a .05 level of significance. These follow-up analyses utilized the Newman-Keuls procedure.

This analysis entailed partitioning the continuous variable of curiosity into the arbitrary categories of high and low curiosity. According to Pedhazur (1973), there is danger in categorization since it can lead to a loss of information resulting in a less sensitive analysis. In essence, all students who were placed in one group or the other were treated as if they had the same score. So that the difference of just one point would not be the deciding factor in group assignment, the three middle scores were eliminated. As reported earlier, this resulted in a loss of 11 subjects but a highly significant p value in differentiating the two groups ($p = .0001$). All 84 subjects were administered the treatments, however, as not doing so would have raised suspicions (and anger) among the subjects left out of this phase of the study.

Block randomization of subjects to the treatment groups was used to control for differences in prior knowledge of museums, ability level, and other factors.

RESULTS

Analysis

A 2 X 2 analysis-of-variance factorial design was computed to test whether performance on the achievement test was related to the treatment, curiosity, or the interaction of treatment and curiosity. Since there were unequal numbers in the cells, the general linear models procedure was used. The results indicated that there was overall significance in the model, $F(3,67) = 3.54$, $p = .0191$. There was a significant main effect for curiosity ($p < .01$). There was no main effect for treatment. No significant interaction was found. Results of this analysis are reported in Table 1. Type III Sums of Squares are reported in the table since unequal sample sizes were used.

Subjects in the Advisement treatment scored only marginally and non-significantly higher ($M = 15.62$) than subjects in the No Advisement treatment ($M = 15.22$). The hypothesis that subjects in the Learner Control with Advisement treatment would score significantly higher overall than subjects in the Learner Control Without Advisement treatment was not supported. Table 2 presents the means, standard deviations, and range of scores on the achievement test for the two treatments. The standard deviations were virtually the same for each treatment. The range of scores was quite similar in both treatments as well. While there was no *overall* significant difference between treatments, there was, however, a significant interaction between grade level and treatment, $F(1,63) = 4.43$, $p < .05$. Post hoc comparisons using the Newman-Keuls Test showed that first graders in the Advisement treatment ($n = 18$, $M = 16.39$) scored significantly higher than first

grade students in the No Advisement treatment (n = 21, M = 12.33). The opposite was true for the 2nd grade subjects with those receiving No Advisement (n =16, M = 19.00) performing significantly better than those receiving Advisement (n = 16, M = 14.75). Figure 3 illustrates this interaction.

Table 3 presents the descriptive statistics for the achievement test score based on curiosity. The difference in mean scores on achievement between the two groups is quite large (difference = 5.03 points) in favor of the high curiosity group. Therefore, the hypothesis that high curious subjects would perform better in an interactive learner control lesson than low curious subjects regardless of treatment was supported. Overall, high curious subjects received significantly higher scores on the achievement test (M = 17.89) than low curious subjects (M = 12.86). The range of scores also reflects a dramatic difference with the highest score in the high curiosity group and the lowest score in the low curiosity group.

Table 4 presents the descriptive statistics for the achievement test scores by treatment and curiosity groups. High curious subjects performed slightly better, although not significantly, in the No Advisement treatment (M = 18.39) than they did in the Advisement treatment (M = 17.39). Also, high curious subjects in the No Advisement treatment scored significantly higher (M = 18.39) than low curious subjects in the Advisement treatment (M = 13.63) at the $p < .05$ level with the Newman-Keuls test. Low curious subjects did score higher in the Advisement treatment (M = 13.63) than low curious subjects in the No Advisement treatment (M = 12.21) but the difference was not significant at the $p < .05$ level (see Figure 4).

There were no main effects for grade level although second graders achieved higher scores (n = 32, M = 16.88) than first graders (n = 39, M = 14.20) on the achievement test. There was also no significant interaction between grade level and curiosity on performance on the achievement test suggesting that curiosity was not affected by the higher level of verbal and communication skills of the second graders.

There was no significant main effect for gender. Males and females performed equally regardless of which lesson treatment they received. Most importantly, however, no interaction between gender and curiosity suggests that curiosity is not affected by gender differences. High curious females (n = 18) scored only slightly higher (M = 18.17) than high curious males (n = 18, M = 17.61) while low curious males (n = 13) scored slightly higher (M = 13.15) than low curious females (n = 22, M = 12.68).

Table 1

Analysis of Variance Tests of Hypotheses

Source	df	SS	MS	F
Curiosity	1	436.91	436.91	9.77*
Treatment	1	0.76	0.76	0.02
Curiosity*Treatment	1	25.77	25.77	0.58
Error	67	2997.16	44.74	

* $p < .01$

Table 2

Achievement Test Scores: Descriptive Statistics by Treatment Group

Variable (treatment)	N	Mean	Std. Dev.	Minimum Score	Maximum Score
No Advisement	37	15.22	7.17	4.00	40.00
Advisement	34	15.62	7.00	3.00	38.00

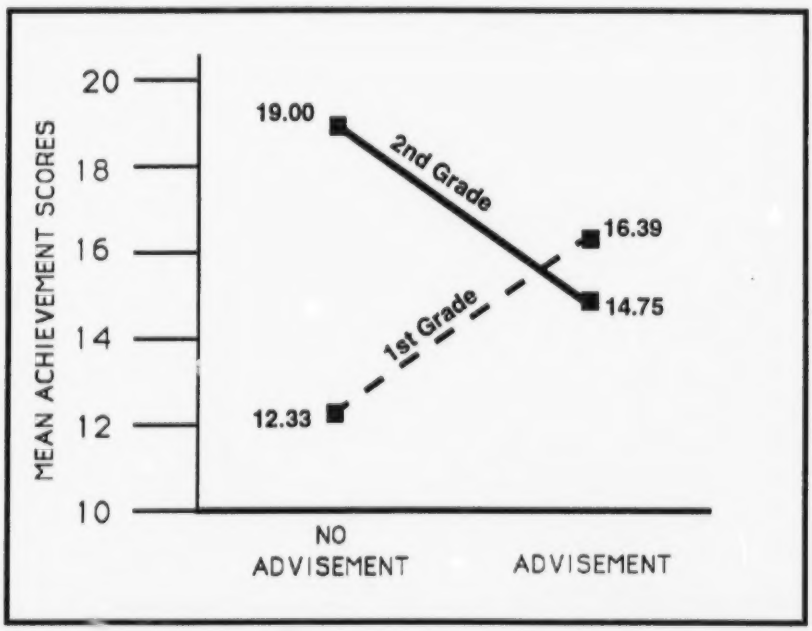

FIGURE 3 ☐ Mean Achievement Scores by Treatment and Grade Level

Table 3

Achievement Test Scores: Descriptive Statistics by Curiosity Groups

Variable (Curiosity)	N	Mean	Std. Dev.	Minimum Score	Maximum Score
Low	35	12.86	5.98	3.00	29.00
High	36	17.89	7.19	8.00	40.00

Table 4

Achievement Test Scores: Descriptive Statistics by Treatment and Curiosity Groups

Variable Treatment	Curiosity	N	Mean	Std. Dev.	Minimum Score	Maximum Score
No Advisement	Low	19	12.21	5.58	4.00	23.00
	High	18	18.39	7.43	8.00	40.00
Advisement	Low	16	13.63	6.52	3.00	29.00
	High	18	17.39	7.11	8.00	38.00

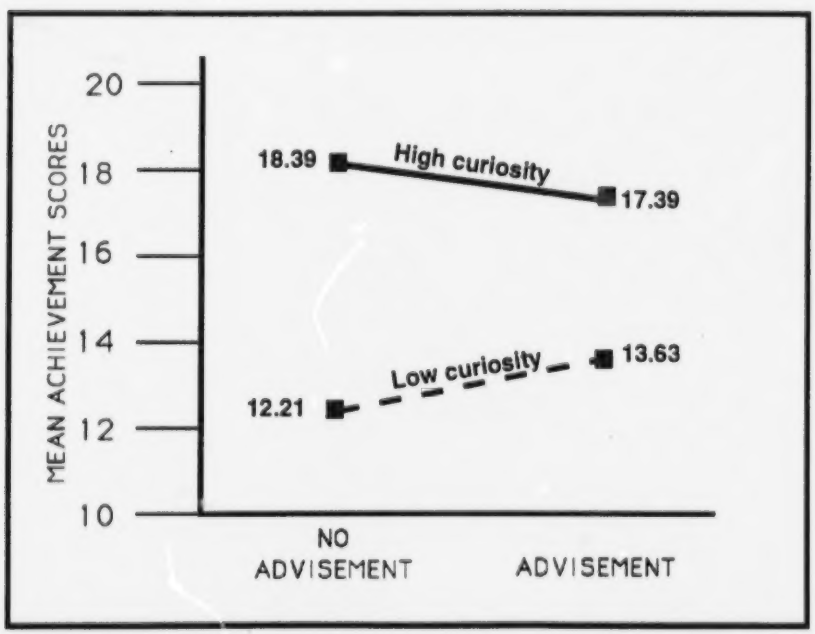

FIGURE 4 ☐ Mean Achievement Scores by Treatment and Curiosity

In-Treatment Data: Time on Task, Curiosity, and Treatment

Time on task is the actual length of time the subject spent in the lesson; therefore, the time spent in the pre-lesson warm-up or the time spent in administration of the achievement test was not included. After the subject received a pre-lesson warm-up which averaged 3.26 minutes, the narrator instructed the subject to "touch the screen when you are ready to begin your visit." The computer tallied time in treatment from the moment the subject touched the screen to the conclusion of the treatment. Due to computer error, 9 subjects' time data were lost. To determine if there was a relationship between time on task and treatment, curiosity, and grade level, an analysis of variance was conducted. The analysis indicated that there was overall significance in the model, $F(7,54) = 3.94$, $p < .01$. Significant main effects existed for treatment ($p < .05$) but not for curiosity or grade level at the $p < .05$ level. Subjects in the Advisement treatment ($n = 34$, $M = 15.4$) spent approximately two minutes longer in the lesson than subjects in the No Advisement treatment ($n = 28$, $M = 13.2$). No significant interactions existed at the $p < .05$ level. Figure 5 shows the interaction of curiosity and treatment on time on task.

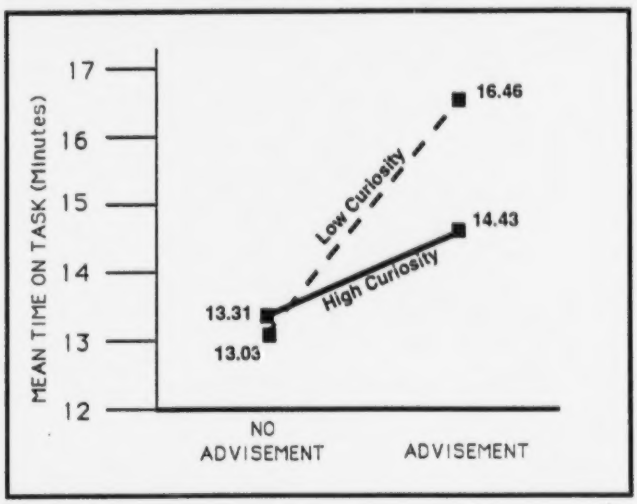

FIGURE 5 ☐ Mean Time on Task: Interaction of Curiosity and Treatment

In-Treatment Data: Learner Control Decisions

In addition to time on task, in-treatment data collected included decisions made by the subject related to other learner control options such as sequencing, remediation, "Stop and Look," and exiting, as well as subjects' response to advisement.

Sequencing. Most subjects availed themselves of the opportunity to sequence their material. Eighty-nine percent (89%, n = 63) of the subjects chose a sequence of content presentation different from the sequential order of the menu options. Only 11% (n = 8) of the subjects chose the sequential order of menu options. Thirty-seven and one half percent (37.5%, n = 3) of these children were in the high curious group while 62.5% (n = 5) were in the low curious group.

Exiting. Almost all of the subjects (87%, n = 62) stayed in the lesson. Of the 13% (n = 9) that chose to exit, 56% (n = 5) were low curious while 44% (n = 4) were high curious.

Remediation. Most children either did not require remediation or chose remediation when it was offered the first time. Of the 71 subjects, 20 subjects (28%) needed remediation and were asked if they would like to receive remediation after an incorrect response. Sixteen of those subjects (80%) chose to be remediated when it was offered. Four subjects (20%) responded "No" to the offer of remediation. Two of those four were in the Advisement treatment and both decided to be remediated *after* receiving the advisement.

Advisement. When advisement was offered, it was most often heeded. Unfortunately, most children did not get to that point. Of those who exited and then received advisement to return to the lesson (n = 6), 67% heeded the advisement and returned to the lesson while 34% (n = 3) chose to ignore the advisement.

As discussed under remediation, only two children who chose not to be remediated were in the advisement treatment. Both those children heeded the advisement and ultimately received the remediation.

"Stop and Look" and "Stop and Think" were the other forms of advisement which were built into the lesson. While only the Advisement treatment offered the opportunity to "Stop and Think;" both treatments offered the opportunity to "Stop and Look;" the advisement treatment, however, included encouragement to "Stop and Look" as well. The next section discusses the results of the analysis of this particular advisement.

Effect of "Stop and Look" advisement. While second graders showed little difference in the mean number of times they used the "Stop and Look" option between the No Advisement treatment ($\underline{M}$ = 1.37) and the Advisement treatment ($\underline{M}$ = 1.50), the difference between the first graders in the No Advisement treatment ($\underline{M}$ = .95) and first graders in the Advisement treatment ($\underline{M}$ = 2.33), warranted closer examination. An independent means $\underline{t}$-test was conducted with the first graders to determine whether there was a significant difference between the means of the two groups in use of "Stop and Look." The results were significant at the $\underline{p} < .01$ level. It appears that the first graders, then, actually ***heeded*** the advice to "Stop and Look" more so than did the second graders. Figure 6 illustrates this interaction.

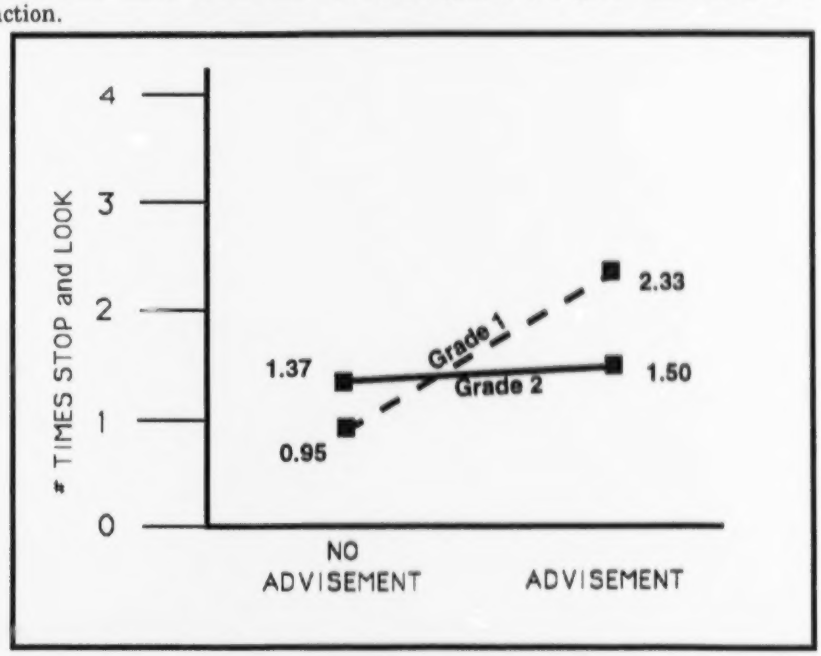

FIGURE 6 ☐ # Times "Stop & Look" Option Used By Grade Level and Treatment

Qualitative Data

Interview data were collected from a random selection of 25 subjects. The interviews were audiotaped. From the 25 subjects interviewed, twenty were transcribed for review; three of the original 25 were in the middle curiosity group who had been dropped from the analysis, and the two remaining subjects' audio recordings were inaudible. The 20 subjects accounted for 28% of the total sample. Through random ch[illegible] subjects interviewed were high curious while eight subjects were low curio[illegible], 11 were males and 9 were females, and 19 had received the Advisement lesson while 1 received the No Advisement lesson. There were 10 first graders and 10 second graders.

The interview was conducted following the treatment and achievement test, and prior to the concluding entertainment video. The purpose of the interviews was to collect data on how subjects felt about the lesson in general, how subjects responded to a learner control environment (since both treatments represented a learner control environment), and why subjects made certain decisions. The interview also provided an opportunity to confirm whether or not the child actually understood the learner control options and assess his/her opinion about them. The average interview lasted approximately 4-5 minutes. In terms of the results, the most explanatory qualitative information received pertained to one of the learner control options, the opportunity to "exit." It must be noted, however, that almost all who were interviewed had received the Advisement lesson which may have influenced them to stay in the lesson.

Overall response to lesson. With the exception of one "I don't know" response all the subjects interviewed had a favorable reaction to the lesson. The most common responses were "It was fun" and "I liked it" when asked what they thought about the lesson they had just finished. When queried further, the subjects varied in what they considered "fun" about the lesson. Some subjects enjoyed the technological aspects of the lesson such as the opportunity to "touch" the computer screen and make things happen, while other subjects actually mentioned the content as in "...My favorite part about it was the big sculptures at the beginning, and the artists were neat and the different kinds of portraits and stuff."

Exiting. Most children did not exit the lesson as indicated by the lesson log completed by the administrators. This undoubtedly contributed to the lack of treatment effects. Had more children exited, it would have been possible to determine the effect of advisement on their decisions to re-enter the lesson or not. The interviews helped to explain why more children never got to this advisement. Typically, the children responded that they did not exit because they either were enjoying their experience or were interested in what else would be coming up in the lesson. Again, the children interviewed were mostly in the Advisement lesson and may have felt more comfortable about staying in the lesson as a result. Only 13% of the 71 subjects chose to exit. The following is a typical exchange of those interviewed.

Interviewer
Remember that big red button?

Child
Yeah. That was the exit.

Interviewer
That's correct. You never touched that exit button. Why didn't you ever press the exit button?

Child
I don't know. I just wanted to see what else was there.

The above excerpt was taken from an interview with a high curious child. The responses from low curious children were similar. The following excerpt is from an interview with a low curious child.

Interviewer
I noticed that you didn't use the big red button. Do you remember that red button?

Child
Yeah.

Interviewer
What did that red button stand for?

Child
Um, if you didn't want to do that anymore.

Interviewer
That's right. You could what?

Child
Stop.

Interviewer
Stop. You could just get right out of the lesson. But, you never pushed that red button. How come?

Child
Because I liked it.

A particularly enthusiastic second grader (high curious) had this exchange with the interviewer:

Interviewer
Did you ever exit, touch the red button?

Child
No.

Interviewer
How come?

Child
Because I thought it was really interesting just looking at what I picked. I didn't even pay any attention [to the red button] it was so cool. I just liked what I picked.

Learner Control. Regardless of whether a child was in the Advisement or the No Advisement treatment, they were functioning in a learner control environment in which they had to make decisions about their own learning. The children were asked about what it felt like to make their own decisions as well as asked what kind of decisions they made. It should be noted once again that more high curious subjects were interviewed than low curious subjects so it is difficult to make general statements regarding the low curious subjects.
All high curious subjects and five of the seven low curious children enjoyed being able to make their own decisions in the lesson. When queried, most of them remembered at least some of the actual decisions they made such as the order in which they selected the content or whether they used options such as "Stop and Look." The first exchange takes place with a low curious female who had received the Advisement treatment.

Interviewer
In a lesson like this, you get to make lots of decisions. Like what you will learn about, whether to exit, whether to practice more if you get a wrong answer, and things like that. In this lesson, you're the boss. What does it feel like being the boss? [making decisions in the lesson]

Child
It feels good. Like you're controlling yourself.

Interviewer
Is that a good feeling being able to control yourself?

Child
Yeah.

Interviewer
Do you get to do that much in your life at your age?

Child
Well...[pause]...not always. Like if I go in my room, I have a sign on my door that tells people that they have to knock. And then I can control myself when I'm in the room, but, like in school I have to do certain things and stuff like that.

Interviewer
And how is this [lesson] different?

Child
Well, you can choose the things that you want to do and that you would like to see...

The reference to "control" was used by this high curious male subject as well...

Interviewer
...What was that like...to be the boss?

Child
It was like I was controlling the whole world or the country.

Interviewer
And how did that feel to you?

Child
It felt like I was George Washington or the Governor of the World!

The low curious female in the following excerpt did not like the idea of exploring information on her own.

Interviewer
Do you like people telling you about the information, or do you like to investigate and find information out yourself?

Child
I like people telling me...

The qualitative data although sampling only 28% of the subjects, helped to illuminate issues such as the lack of treatment differences.

Overall, the high curious children in this study responded to an interactive learner control environment more effectively than the low curious children regardless of which lesson they received as indicated by performance on an achievement test related to the lesson content.

DISCUSSION

The emergence of interactive learning technologies provides educators, designers and developers with an opportunity and a challenge to meet the individual needs of different types of learners. To achieve desired instructional outcomes, the educator or designer must consider various *instructional variables* in order to prescribe an appropriate instructional method (Reigeluth, 1983). For this study, the instructional variable explored was learner curiosity. The method explored was learner control. Learner control as it relates to individual differences is an important issue. While research exists in the separate areas of learner control and curiosity, there is little known about the relationship between these variables and what effect they have on learning.

This study built upon the Arnone and Grabowski (1992) research on the effects of variations in learner control on young children's learning. That study showed that young learners demonstrated significantly better achievement in a learner control lesson which incorporated advisement than one in which the learner received no advisement.

The Arnone and Grabowski (1992) study did not look at individual differences in trait curiosity. A learner control environment might be experienced differently by individuals who vary in trait curiosity. The curiosity research suggests that individuals have different tolerance levels for arousal potential (Day & Berlyne, 1971). Varying degrees of learner control, then, may present different levels of arousal potential depending on the individual. Examination of the two separate literatures provided a basis for a conceptualization of a theoretical framework for the hypotheses presented in the study.

Curiosity

Curiosity and Learner Control

High curious subjects were predicted to perform better than low curious subjects in either learner control environment. High curious subjects, having a higher tolerance for uncertainty and the unfamiliar, should be more efficient in a learner control environment. Low curious subjects, on the other hand, may feel overstimulated or become anxious or disinterested in such a learning situation. The results of this study supported that prediction ($p < .01$). High curious children achieved significantly higher scores on an achievement test than low curious children after being exposed to a learner control lesson, regardless of treatment. This would support the theoretical argument that individuals have different optimal levels of arousal. What is the appropriate amount of stimulation for one person may not be enough or may be too much for another.

In addition to the art education content, a certain amount of arousal inducing stimuli were present in this lesson by virtue of its being a learner control environment. Such stimuli included use of touch screen, choice of menu options, and use of other learner control options such as pacing, remediation, exiting, "Stop and Look" and, in the Advisement lesson, the length of time to spend in the "Stop and Think" mode. Taken together, the stimuli described above could be considered rather high in *collative variability*, a construct used by Berlyne (1960. *Collative variability* refers to how complex a stimulus is and how easy or difficult it is for the individual to collate, or compare with stimuli with which he/she is already familiar. While collative properties have the potential of increasing arousal level and inducing curiosity, Day and Berlyne (1971) state that different individuals will vary

in their preference and tolerance for arousal potential. In this lesson, the high curious subjects were able to function efficiently, both assimilating the content and collating the various stimuli presented via the learner control format.

On the other hand, the low curious subjects may have spent more of their effort in attempting to collate the various stimuli of a learner control lesson which limited their efficiency in terms of assimilating the necessary content. This was reflected in lower achievement scores.

The results of this study provide some evidence to demonstrate that curiosity is an important factor in either learner control environment. These high curious students functioned better in this situation than the low curious students. However, it is not known how these high curious students would have performed in a program control environment. The high curious subjects hypothetically would perform less well in a program control environment because the amount of stimuli would be *less* than optimal for them. For the low curious students, program control may have the appropriate amount of stimuli for them, resulting in more efficient learning. In the present study, it is likely that the low curious subjects experienced both treatments as at least somewhat high in degree of uncertainty. Further research is needed to explore this as well as research to investigate the effect of low uncertainty (e.g., program control) on learning in low curious subjects since this study did not include program control. Fry (1972), for example, found that high aptitude/highly inquisitive subjects learned significantly more in what that author called a high degree of student control (what is referred to as learner control in this study) while high-aptitude/low-in-inquisitiveness subjects performed significantly better given a low degree of student control.

Alternative Explanation: Why Subjects Did Not "Exit"

Earlier, several explanations were offered to explain why more subjects did not exit the lesson. (By not exiting, they never received the advisement pertaining to the exit decision which lessened the effect of the Advisement treatment.) One suggestion was that most children did not leave because they were engaged in the lesson and simply wanted to remain in the lesson. The randomly selected interviews, representing 28% of the sample, substantiated this. (It should be repeated that only eight low curious subjects as opposed to 12 high curious subjects were interviewed, and most subjects interviewed had received the advisement lesson.) Exiting would have provided the low curious subjects a means to limit their stimulation by actually withdrawing from the source of it, the learner control lesson itself. Yet, 85% (n = 31) of the low curious subjects remained in the lesson. The following paragraphs offer an alternative explanation for why more low curious subjects did not exit.

Since the subjects in this study were young and inexperienced, exiting the lesson might have represented to them a choice that was even more unfamiliar to them than the lesson itself which provided them with some regularity of format and presentation. In other words, the longer they stayed in the lesson, the less likely it became that they would exit since some of the uncertainty of a learner control environment diminished simply as a result of staying in the lesson. For example, as more time was spent in the lesson, they became familiar with the sound of the narrator's voice, and with the format of practice items and with touching the screen. The lesson itself became the more familiar scheme while the red exit button may have embodied an object of uncertainty. Not yet having touched it, it was something that might have represented some cognitive conflict: what really would happen if the red button were touched?--perhaps the screen would become black, perhaps it would mean an immediate return to the classroom, and so on.

Even though they had been told in the pre-lesson warm-up that the lesson would end if they touched the red button, if they had never actually done it in the lesson, it would represent an unexplored stimulus.

If the above explanation is true, it would follow that an individual who prefers a lower level of arousal would choose to ignore this thus far unexplored and therefore unfamiliar button, a button which posed an additional source of collative variability. This explanation can be related to Day and Berlyne's statement about collative properties and response conflict:

> Collative properties act by inducing a state of *response conflict*, i.e., uncertainty about the nature of the stimulus and thus a conflict among the various response tendencies toward it. (1971, p. 313)

It is possible, then, that uncertainty about the nature of the exit button induced a response in these learners which may have been resolved by avoidance.

Effect of Advisement on Low Curious Subjects

There was a difference of 1.4 points between treatments in favor of the Advisement treatment with low curious subjects. The minimum significant difference was 3.17 and therefore this difference was not statistically significant at the .05 level. The treatments were equalized because students often did not receive the advisements related to exiting and remediation. They did not receive the exit advisement because they did not press the exit button; they did not receive the remediation advice because they generally took the remediation when offered.

The advice to "Stop and Look" in the Advisement treatment did make a difference, however, in the number of times that the option was used by low curious subjects. Low curious subjects responded to the advisement to "Stop and Look" significantly more times in the advisement treatment ($\underline{M} = 2.06$) than did the low curious subjects in the No Advisement treatment ($\underline{M} = 1.16$). The minimum significant difference was 0.826; the difference was significant at the $\underline{p} < .05$ level. This seems to indicate that this advisement in the Advisement treatment did reduce some of the uncertainty associated with that stimulus as compared to the No Advisement treatment. What this suggests overall is that such advisements did make a difference for the low curious subjects in that they responded to them (as evidenced by the use of them), but on its own it was not enough to make a statistical difference in scores between the treatments. It might further be suggested that low curious subjects will respond to advisement if advisement is received. In the case of exiting and remediation, such advisement was not received for most of the subjects.

Perhaps, more such strategies along the lines of "Stop and Look" and "Stop and Think" embedded in the lesson would have cumulatively contributed to making advisement more beneficial to low curious students.

Treatment

Diminished Power of Treatment

One explanation for the lack of a main effect for treatment was that the differences between the treatments were diminished because most subjects in the advisement treatment did not get the full benefit of each aspect of advisement.

Remediation. Most of the subjects in the Advisement treatment took remediation the first time it was offered and thus never had advisement pertaining to remediation. The subjects in the No advisement treatment also took the

remediation when offered. This may have contributed to the lack of differences between the groups which would have been attributed to receiving or not receiving advisement on remediation.

Exiting. Another possible reason for no main effect for treatment was that very few children exited the program. In the Advisement treatment, if a child exited, he/she would have received a prompt like this: "Are you sure you want to leave now? There's lots more for you to discover. This next section is very interesting." The advisement, then, gave the child the opportunity to reconsider his/her decision and re-enter the lesson. To receive the advisement, however, the child must first have pressed the exit button. Had more children in both treatments exited, it would have been possible to sense the effect of this advisement on performance in the achievement test. That is, those that heeded the advisement and re-entered the lesson would be expected to demonstrate higher achievement scores than those who did not heed the advisement or did not receive the advisement, thus, missing out on some of the content presentation and spending less time on task.

Questions to be resolved include whether the subjects were too afraid to exit (e.g., they may have had the expectation that they were "supposed" to finish) or whether they were too engaged in the lesson to exit. Because of the careful procedures followed in the pre-lesson warm-up, it seems unlikely that the reason children did not press the red exit button was because of perceived expectations that the lesson had to be completed. Each administrator followed a three-step procedure related to the exit button as follows: 1) introduce the child to the red exit button and explain its function, 2) have the child relate his/her understanding of the button's function (to confirm that child understood the directions), and 3) tell the child that it is permissible to use the exit button anytime he/she wants to end the lesson. The last part of the procedure was very important; it was designed to alleviate the child's potential fear of expectations on the part of the administrator that the child had to finish the lesson. It is equally important to note, however, that while the administrator used the three procedures described above to assure that each child understood the meaning and function of the red exit button, the child would not have the opportunity to **actually** exit until he/she was in the actual lesson.

Some children may not have exited because it would have meant returning to their classroom. Working in the CBIV lesson may have seemed more appealing to them than the alternative. Many children had not experienced interactive video prior to the study, and so the novelty effect may also have contributed to keeping them in the lesson.

Another possible reason that most children did not exit is that they were so engaged in the lesson that they wanted to remain in it. The interviews representing 28% of the children helped to corroborate this explanation. A caution, discussed earlier, remains for this explanation since most of those who were interviewed had received the Advisement lesson; therefore, those receiving the No Advisement lesson were under-represented in the interviews. Part of the interview was devoted to exploring reasons for decisions made by the child. The exiting decision was usually discussed as in "I noticed that you did not use the red button to leave the lesson. Why not?" The most typical response was "I didn't want to. It was fun." It may be that children were engaged by the changing elements in the lesson (e.g., new video segments, new content, etc.) and that they attended more to these changing elements than to the static exit button. The child quoted in Chapter 4 as saying "...I didn't even pay any attention [to the red button] it [the

lesson] was so cool," suggests this explanation. Berlyne (1951) states:

> A recently changed stimulus is more likely to be responded to than one which has remained unchanged and has been responded to for some time. (p. 277)

While the exit button would have represented a stimulus which remained "unchanged" as the lesson progressed, it would not have represented a stimulus which had been "responded to for some time" (since most children did not ever respond to the exit button by pressing it). It would thus appear that there may be some other alternative explanation worth investigating. Such an explanation deals with level of curiosity which is discussed later in this chapter.

In sum, not exiting may have had the effect of diminishing the strength of the treatments making them less sensitive to differences due to advisement about exiting decisions.

Power of Treatments Left to Remaining Advisement Strategies

Effectively, the Advisement treatment was differentiated from the No Advisement treatment by the two remaining embedded advisement strategies: 1) "Stop and Look" and 2) "Stop and Think." Although both treatments offered the opportunity to "Stop and Look" at an image whenever a particular icon was present, subjects in the Advisement treatment were also encouraged to use the "Stop and Look" option to explore the images more closely. Subjects in the Advisement treatment were also encouraged to "Stop and Think" periodically as in "What do you suppose you'll find when you go in [the museum]? 'Stop and Think' about it. Then touch the screen when you are ready to go on."

Without the contribution of the remediation and exiting advisements in the Advisement treatment, the strength of the treatment fell to the above remaining advisement strategies. It seems likely that these strategies were not enough on their own to sense the effect of advisement versus no advisement as a main effect. It may be that the two treatments were equalized, in effect, by the subjects' enjoyment of the lesson. It might also have made a difference overall had more embedded advisement strategies been incorporated in the treatment.

Explanation of Grade by Treatment Interaction

Although the power of the treatment may have been diminished overall, the first grade subjects performed significantly better with Advisement than with No Advisement. The opposite was true and significant for second graders. A possible explanation for these results pertains to the remaining advisement strategies and their effect on the younger subjects.

Interpretation of results with first graders. Examination of the in-treatment data showed that the first grade subjects heeded the advisements to "Stop and Think" and "Stop and Look" more so than the older subjects. Evidence supporting this supposition was collected for one of these advisements. Although no data were collected on the time spent in the "Stop and Think" mode, data were collected on the number of times a subject used the "Stop and Look" learner control option. Grade 1 children in the Advisement treatment did use the "Stop and Look" option more times ($\underline{M}$ = 2.33) than did grade 1 children in the No Advisement treatment ($\underline{M}$ = 0.95). The difference was significant at the $\underline{p} < .05$ level using the Newman-Keuls procedure. More importantly, first graders in the Advisement treatment also used the "Stop and Look" learner control option significantly more times than their second grade counterparts in the same treatment ($\underline{M}$ = 1.50), $\underline{p} < .05$. These in-treatment data suggest that the first graders actually heeded the

advisements to a greater degree than the older subjects and may be partly responsible for the better performance of first graders over second graders in the Advisement treatment.

Why would first graders heed advice more than the second graders? One possible explanation is related to the newness of the academic experience for these younger subjects. The first graders were less experienced and may have perceived the voice of the narrator as a reassuring adult authority figure offering encouragement to explore images carefully and to "Stop and Think." They may also have required more guidance as their experience with computers was minimal compared with the second graders.

Interpretation of results with second graders. With second graders, the explanation of the grade by treatment interaction is more nebulous. There was no significant difference between treatments in the use of the "Stop and Look" learner control option with second graders. The second graders actually performed better in the No Advisement treatment than in the Advisement treatment. Why did second graders not heed the advisements as much as the younger subjects? One possible explanation is that computer-based instruction was not as new to these subjects; they perhaps did not sense the need for encouragement from the narrator as much as the younger subjects. Additionally, second graders had more experience with computers in the classroom and may have felt that they were more experienced users and did not need to follow the advice.

What the results seem to indicate is that when advisement is heeded, as in the case of the first graders, it does make a difference. When it is not heeded, as in the case of the second graders, it seems likely that learners can do just as well or better in a learner control lesson without advisement. Furthermore, it seems likely that younger subjects will heed advisement more than older subjects.

Comparison to Bridge Study

This study was at odds with the bridge study in that no main effects for treatment were found. However, the overall significant differences for the bridge study were very closely replicated in the first grade population of the present study. That is, the mean score for subjects in the learner control with advisement treatment in the bridge study was 16.08, while the mean score for first graders in the present study was 16.39. The mean score for the learner control without advisement treatment in the bridge study was 13.35 while the respective score for first graders in the present study was 12.33.

The anomaly seems to have occurred with the second graders who performed contrary to expectations. The bridge study did not isolate the grade variable so comparisons across studies by grade are impossible. However, upon close scrutinization of the data for the present study, an interesting pattern emerges. There were more high curious subjects in the second grade (n = 20) than in the first grade (n = 12). There were also more low curious subjects in the first grade (n = 23) than in the second grade (n = 12). Furthermore, there were more high curious second graders in the No Advisement treatment (n = 10) than there were low curious second grade subjects in the No Advisement treatment (n = 5). It is possible, then, that the high curious subjects who predominated in the No Advisement treatment in the second grade contributed to the unexpectedly high scores in the No Advisement treatment with second graders. Since high curious subjects were expected to experience greater ease in handling the uncertainty of the No Advisement treatment, this is one possible explanation for anomaly which occurred.

Implications for Instructional Design

This study provided empirical support for the hypothesis that high curious children learn better in two types of learner control lessons than low curious children. Such information has implications for the design of instruction whether the delivery of that instruction is in a classroom or via interactive technologies. Based on the findings, it is recommended that educators and designers acquire knowledge about the individual differences in curiosity level among students and determine appropriate methods and strategies to maximize learning in each individual student. If, for example, it is known that a particular child is very low curious, then the child may be overwhelmed in any learner control environment at this point. A high amount of guidance in the way of instructor (classroom) or program (CBIV) control of the lesson would be recommended. In other cases, where the child is mid-to-low in curiosity, a learner control lesson with many embedded strategies to reduce uncertainty and bring the lesson in line with the child's optimal level of arousal potential would be appropriate. A high curious child should feel comfortable in an environment with moderate to high amounts of learner control.

Based on the superior performance of the first grade subjects in the Advisement treatment in this study, and the results in favor of advisement in the Arnone and Grabowski (1992) study, advisement is recommended in a learner control lesson designed for young learners. What seems to be even more important, however, is that advisement must be heeded in order to be successful. Strategies, therefore, must be employed which also encourage students to *heed* advisement.

Suggestions for Future Research

Research needs to be conducted which addresses some of the limitations of the present study. Since the power of the treatments was diminished by the fact that subjects did not use all the advisements, a future study could strengthen the respective treatments by including more learner control options and more opportunities for advisement. In this way, the loss of two advisements as was the case in the present study (i.e., exiting and remediation) would not be as detrimental to sensing the overall effect of the treatments.

Perhaps, research needs to be undertaken which explores who takes advisement and who does not, as well as what strategies are most effective in inducing students to heed advisement. Future studies should also include program control. Although this study predicted that low curious subjects would perform better in an environment where there was less collative variability, program control was not included. Program control would take the learner along a predetermined path and might substantially reduce the uncertainty of the learning environment. A study which includes program control in addition to variations in learner control could be used to investigate the effect on learners of the full range of uncertainty in learner control as depicted in Figure 2.

More psychometric studies need to be conducted to collect data on the curiosity instruments, especially the *Specific Curiosity Scale for Primary Grades (SCSPG)* so that the instruments can continue to be improved in terms of their validity and reliability in measuring curiosity in young subjects.

Is it possible that, with repeated exposure to a learner control environment, the uncertainty associated with this type of learning environment would be reduced? It would seem that low curious subjects might then improve their performance as they became more familiar with the types of stimuli associated with a learner control lesson. These stimuli would include the learner control options in addition to the specific content presented. To research this question, a study could

be designed which collects data over time on the use of learner control lessons and the changes in achievement with increased exposure. A variation of this suggestion would be studies which, using program control initially, gradually reduce the amount of program control while increasing learner control so that learners build up to tolerating higher levels of uncertainty.

Future studies should also be planned which explore the potential for increasing trait curiosity level over time. Berlyne (1960) discussed several studies in which stimuli previously associated with supraoptimal arousal for a child became optimal as the child's experience with the situation increased. A learner control study could, for example, be undertaken which examines the effectiveness of particular instructional design strategies designed to enhance state curiosity (e.g., encouragement to explore with guidance provided, use of questions to arouse interest, encouragement of question-asking behavior, provision of environment in which experimentation can occur, etc.) and determine whether trait curiosity can be enhanced over time through repeated experiences in which state curiosity is increased. In conjunction with the same study or a subsequent study, changes in trait curiosity should be correlated with changes in achievement to determine if there is a significant positive relationship between these two variables as would be predicted.

Finally, the use of physiologic measures may provide physical evidence of an individual's curiosity as measured by arousal during a CBIV lesson. Clariana (1990) found GSR to be correlated highly with measures which are of interest to researchers in the field of instructional design. For example, Raskin (1973) used GSR as a measure of attention. Other researchers have found strong correlations between GSR and attitude self-reports and preference (e.g., Schwartz & Shapiro, 1973).

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